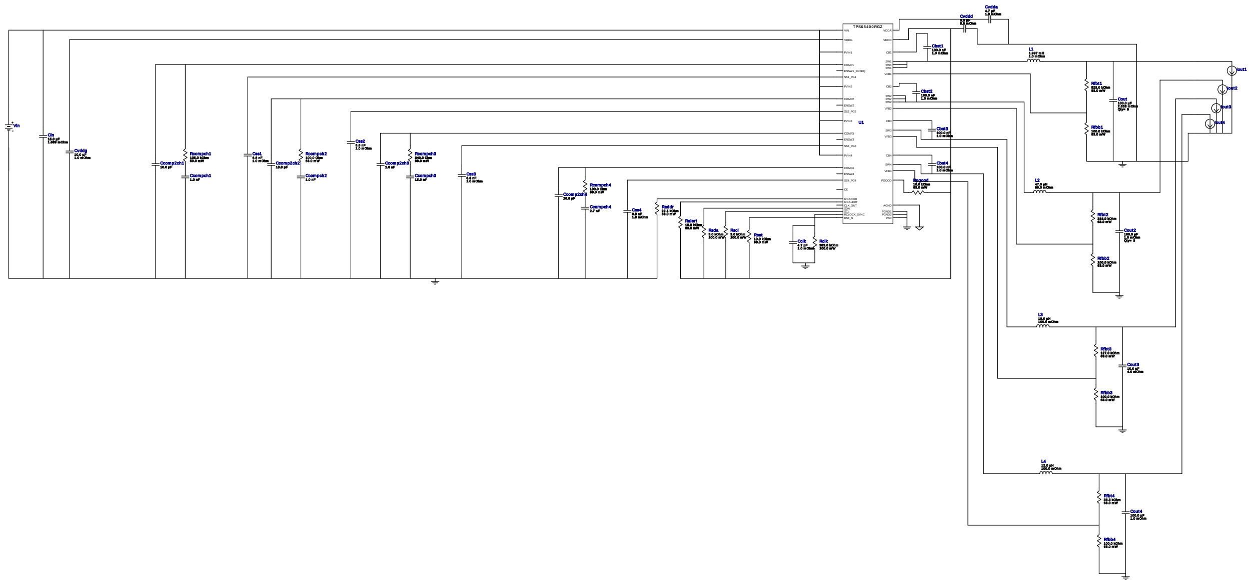
VinMin = 4.5V
VinMax = 18.0V
Vout = 1.8V
Iout = 4.0A

Device = TPS65400RGZR
Topology = Buck
Created = 2025-03-04 08:05:10.674
BOM Cost = NA
BOM Count = 58
Total Pd = 0.47W

WEBENCH ® Design Report

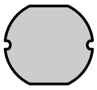
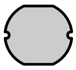
Design : 20 TPS65400RGZR
TPS65400RGZR 4.5V-18V to 1.80V @ 4A



Electrical BOM

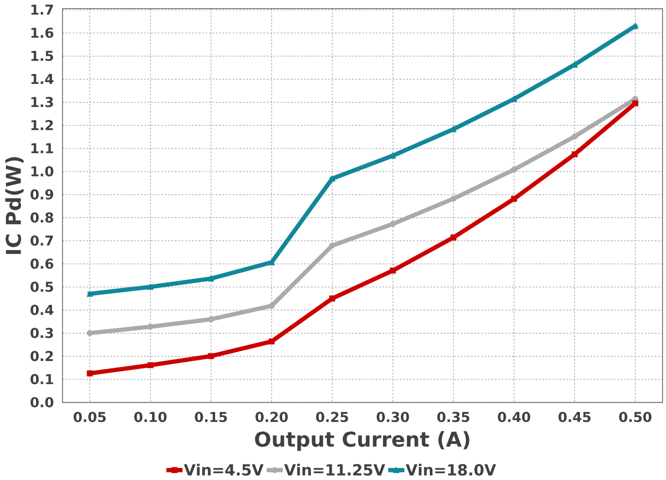
Name	Manufacturer	Part Number	Properties	Qty	Price	Footprint
Cbst1	MuRata	GRM155R71A104KA01D Series= X7R	Cap= 100.0 nF ESR= 1.0 mOhm VDC= 10.0 V IRMS= 0.0 A	1	$0.01	0402 3 mm²
Cbst2	MuRata	GRM155R71A104KA01D Series= X7R	Cap= 100.0 nF ESR= 1.0 mOhm VDC= 10.0 V IRMS= 0.0 A	1	$0.01	0402 3 mm²
Cbst3	MuRata	GRM155R71A104KA01D Series= X7R	Cap= 100.0 nF ESR= 1.0 mOhm VDC= 10.0 V IRMS= 0.0 A	1	$0.01	0402 3 mm²
Cbst4	MuRata	GRM155R71A104KA01D Series= X7R	Cap= 100.0 nF ESR= 1.0 mOhm VDC= 10.0 V IRMS= 0.0 A	1	$0.01	0402 3 mm²
Cclk	MuRata	GRM1555C1H4R7CA01D Series= C0G/NP0	Cap= 4.7 pF ESR= 1.0 mOhm VDC= 50.0 V IRMS= 0.0 A	1	$0.01	0402 3 mm²
Ccomp2ch1	Yageo	CC0805JRNPO9BN100 Series= C0G/NP0	Cap= 10.0 pF VDC= 50.0 V IRMS= 0.0 A	1	$0.01	0805 7 mm²
Ccomp2ch2	Yageo	CC0805JRNPO9BN100 Series= C0G/NP0	Cap= 10.0 pF VDC= 50.0 V IRMS= 0.0 A	1	$0.01	0805 7 mm²
Ccomp2ch3	Samsung Electro-Mechanics	CL21C102JBCNNNC Series= C0G/NP0	Cap= 1.0 nF VDC= 50.0 V IRMS= 0.0 A	1	$0.01	0805 7 mm²
Ccomp2ch4	Yageo	CC0805JRNPO9BN100 Series= C0G/NP0	Cap= 10.0 pF VDC= 50.0 V IRMS= 0.0 A	1	$0.01	0805 7 mm²

Name	Manufacturer	Part Number	Properties	Qty	Price	Footprint
Ccompch1	Samsung Electro-Mechanics	CL21C102JBCNNNC Series= C0G/NP0	Cap= 1.0 nF VDC= 50.0 V IRMS= 0.0 A	1	$0.01	0805 7 mm^2
Ccompch2	Samsung Electro-Mechanics	CL21C102JBCNNNC Series= C0G/NP0	Cap= 1.0 nF VDC= 50.0 V IRMS= 0.0 A	1	$0.01	0805 7 mm^2
Ccompch3	TDK	C2012C0G1H153J085AA Series= C0G/NP0	Cap= 15.0 nF VDC= 50.0 V IRMS= 0.0 A	1	$0.06	0805 7 mm^2
Ccompch4	TDK	C2012C0G1H272J060AA Series= C0G/NP0	Cap= 2.7 nF VDC= 50.0 V IRMS= 0.0 A	1	$0.03	0805 7 mm^2
Cin	TDK	C2012X5R1V156M125AC Series= X5R	Cap= 15.0 uF ESR= 1.669 mOhm VDC= 35.0 V IRMS= 5.0498 A	1	$0.20	0805 7 mm^2
Cout	TDK	C3216X5R1A107M160AC Series= X5R	Cap= 100.0 uF ESR= 2.838 mOhm VDC= 10.0 V IRMS= 4.3069 A	8	$0.46	1206_190 11 mm^2
Cout2	MuRata	GRM32EC80J107ME20L Series= X6S	Cap= 100.0 uF ESR= 1.0 mOhm VDC= 6.3 V IRMS= 6.0 A	3	$0.17	1210_270 15 mm^2
Cout3	MuRata	GRM31CR71E106KA12L Series= X7R	Cap= 10.0 uF ESR= 4.0 mOhm VDC= 25.0 V IRMS= 6.0 A	1	$0.06	1206_180 11 mm^2
Cout4	MuRata	GRM32EC80J107ME20L Series= X6S	Cap= 100.0 uF ESR= 1.0 mOhm VDC= 6.3 V IRMS= 6.0 A	1	$0.17	1210_270 15 mm^2
Css1	MuRata	GRM155R71E682KA01D Series= X7R	Cap= 6.8 nF ESR= 1.0 mOhm VDC= 25.0 V IRMS= 0.0 A	1	$0.01	0402 3 mm^2
Css2	MuRata	GRM155R71E682KA01D Series= X7R	Cap= 6.8 nF ESR= 1.0 mOhm VDC= 25.0 V IRMS= 0.0 A	1	$0.01	0402 3 mm^2
Css3	MuRata	GRM155R71E682KA01D Series= X7R	Cap= 6.8 nF ESR= 1.0 mOhm VDC= 25.0 V IRMS= 0.0 A	1	$0.01	0402 3 mm^2
Css4	MuRata	GRM155R71E682KA01D Series= X7R	Cap= 6.8 nF ESR= 1.0 mOhm VDC= 25.0 V IRMS= 0.0 A	1	$0.01	0402 3 mm^2
Cvdda	MuRata	GRM155R61A475MEAAD Series= X5R	Cap= 4.7 uF ESR= 1.0 mOhm VDC= 10.0 V IRMS= 0.0 A	1	$0.02	0402_065 3 mm^2
Cvddd	Kemet	C0805C335K8PACTU Series= X5R	Cap= 3.3 uF ESR= 5.0 mOhm VDC= 10.0 V IRMS= 8.13 A	1	$0.07	0805 7 mm^2
Cvddg	Taiyo Yuden	LMK212BJ106KG-T Series= X5R	Cap= 10.0 uF ESR= 1.0 mOhm VDC= 10.0 V IRMS= 0.0 A	1	$0.02	0805 7 mm^2
L1	CUSTOM	CUSTOM	L= 1.997 mH 1.0 mOhm	1	NA	CUSTOM 0 mm^2
L2	Wurth Elektronik	7447720470	L= 47.0 µH 89.0 mOhm	1	$0.55	WE-TI_8095 96 mm^2

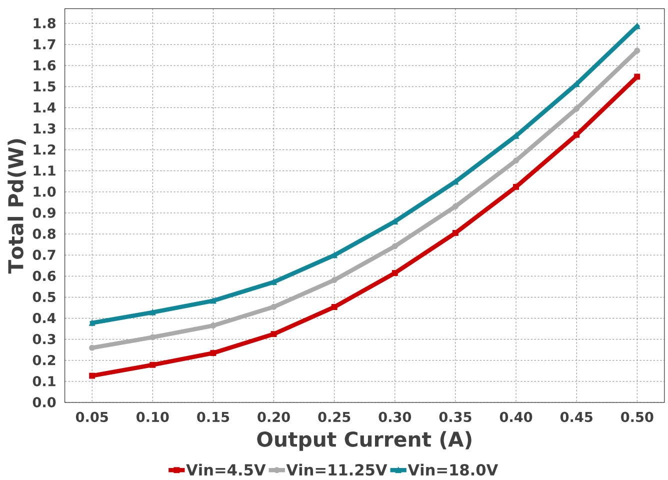
Name	Manufacturer	Part Number	Properties	Qty	Price	Footprint
L3	NIC Components	NPI75C180MTRF	L= 18.0 µH 100.0 mOhm	1	$0.11	 IND_NPI75C 94 mm^2
L4	NIC Components	NPI54C120MTRF	L= 12.0 µH 100.0 mOhm	1	$0.09	 IND_NPI54C 61 mm^2
Raddr	Vishay-Dale	CRCW040222K1FKED Series= CRCW..e3	Res= 22.1 kOhm Power= 63.0 mW Tolerance= 1.0%	1	$0.01	0402 3 mm^2
Ralert	Vishay-Dale	CRCW040210K0FKED Series= CRCW..e3	Res= 10.0 kOhm Power= 63.0 mW Tolerance= 1.0%	1	$0.01	0402 3 mm^2
Rclk	Yageo	RC0603FR-07383KL Series= ?	Res= 383.0 kOhm Power= 100.0 mW Tolerance= 1.0%	1	$0.01	0603 5 mm^2
Rcompch1	Yageo	RC0201FR-07105KL Series= ?	Res= 105.0 kOhm Power= 50.0 mW Tolerance= 1.0%	1	$0.01	0201 2 mm^2
Rcompch2	Vishay-Dale	CRCW0402100RFKED Series= CRCW..e3	Res= 100.0 Ohm Power= 63.0 mW Tolerance= 1.0%	1	$0.01	0402 3 mm^2
Rcompch3	Vishay-Dale	CRCW0402340RFKED Series= CRCW..e3	Res= 340.0 Ohm Power= 63.0 mW Tolerance= 1.0%	1	$0.01	0402 3 mm^2
Rcompch4	Vishay-Dale	CRCW0402100RFKED Series= CRCW..e3	Res= 100.0 Ohm Power= 63.0 mW Tolerance= 1.0%	1	$0.01	0402 3 mm^2
Rfbb1	Vishay-Dale	CRCW0402100KFKED Series= CRCW..e3	Res= 100.0 kOhm Power= 63.0 mW Tolerance= 1.0%	1	$0.01	0402 3 mm^2
Rfbb2	Vishay-Dale	CRCW0402100KFKED Series= CRCW..e3	Res= 100.0 kOhm Power= 63.0 mW Tolerance= 1.0%	1	$0.01	0402 3 mm^2
Rfbb3	Vishay-Dale	CRCW0402100KFKED Series= CRCW..e3	Res= 100.0 kOhm Power= 63.0 mW Tolerance= 1.0%	1	$0.01	0402 3 mm^2
Rfbb4	Vishay-Dale	CRCW0402100KFKED Series= CRCW..e3	Res= 100.0 kOhm Power= 63.0 mW Tolerance= 1.0%	1	$0.01	0402 3 mm^2
Rfbt1	Vishay-Dale	CRCW0402523KFKED Series= CRCW..e3	Res= 523.0 kOhm Power= 63.0 mW Tolerance= 1.0%	1	$0.01	0402 3 mm^2
Rfbt2	Vishay-Dale	CRCW0402316KFKED Series= CRCW..e3	Res= 316.0 kOhm Power= 63.0 mW Tolerance= 1.0%	1	$0.01	0402 3 mm^2
Rfbt3	Vishay-Dale	CRCW0402127KFKED Series= CRCW..e3	Res= 127.0 kOhm Power= 63.0 mW Tolerance= 1.0%	1	$0.01	0402 3 mm^2
Rfbt4	Vishay-Dale	CRCW040238K3FKED Series= CRCW..e3	Res= 38.3 kOhm Power= 63.0 mW Tolerance= 1.0%	1	$0.01	0402 3 mm^2
Rpgood	Vishay-Dale	CRCW040210K0FKED Series= CRCW..e3	Res= 10.0 kOhm Power= 63.0 mW Tolerance= 1.0%	1	$0.01	0402 3 mm^2
Rscl	Yageo	RC0603FR-073KL Series= ?	Res= 3.0 kOhm Power= 100.0 mW Tolerance= 1.0%	1	$0.01	0603 5 mm^2
Rsda	Yageo	RC0603FR-073KL Series= ?	Res= 3.0 kOhm Power= 100.0 mW Tolerance= 1.0%	1	$0.01	0603 5 mm^2

Name	Manufacturer	Part Number	Properties	Qty	Price	Footprint
Rset	Vishay-Dale	CRCW040210K0FKED Series= CRCW..e3	Res= 10.0 kOhm Power= 63.0 mW Tolerance= 1.0%	1	$0.01	0402 3 mm²
U1	Texas Instruments	TPS65400RGZR	Switcher	1	$1.82	RGZ0048B 81 mm²

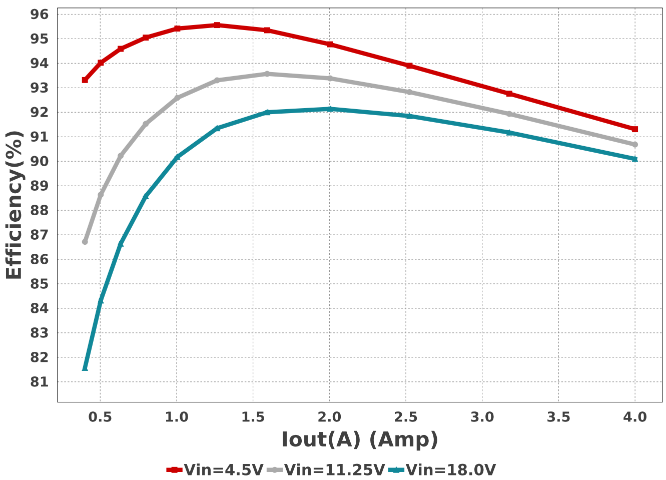
IC Pd



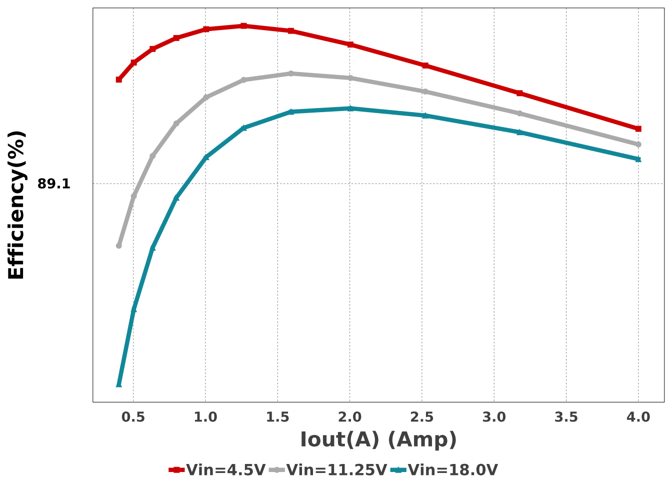
Total Pd



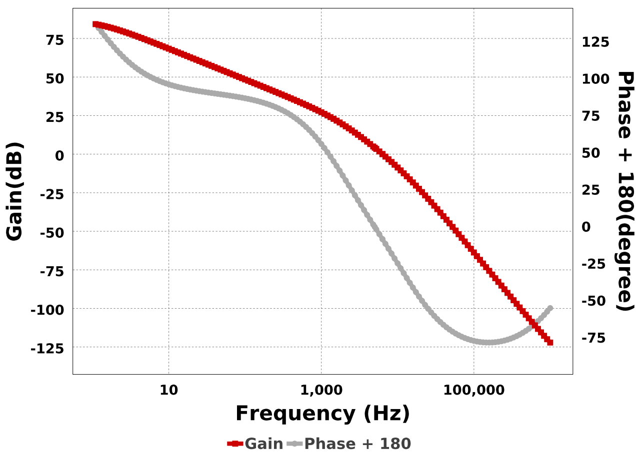
Efficiency



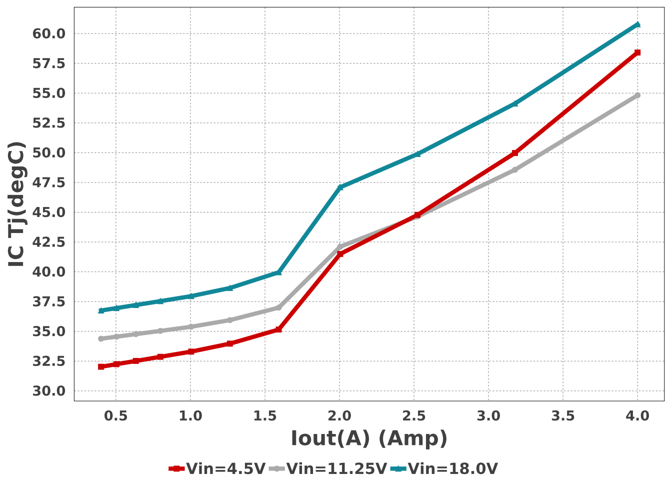
Efficiency(Log chart)

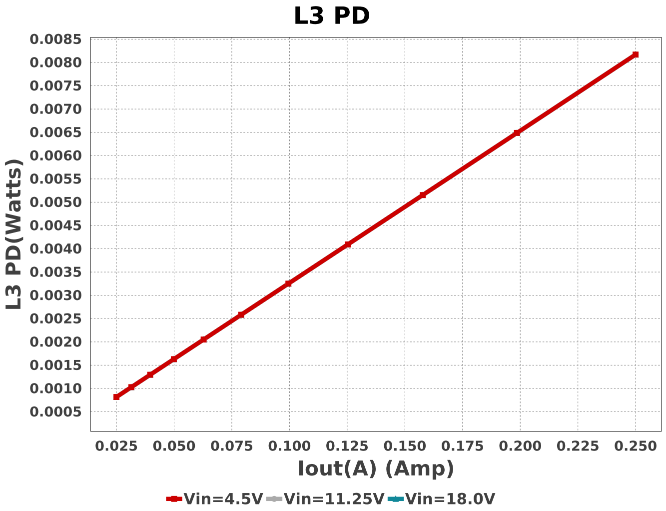


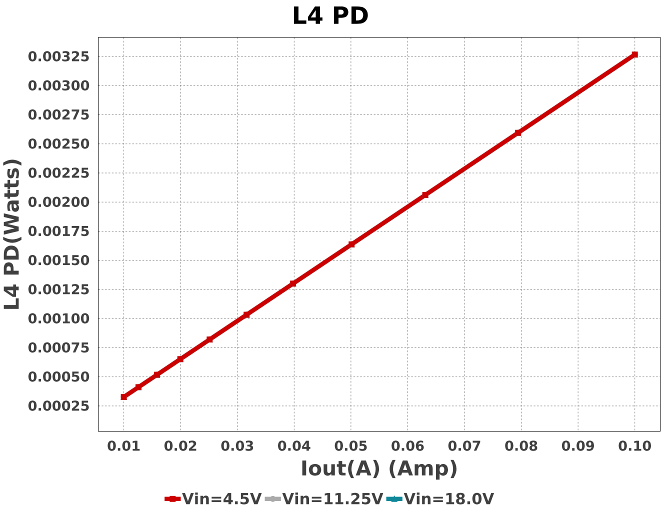
Loop Response Channel2

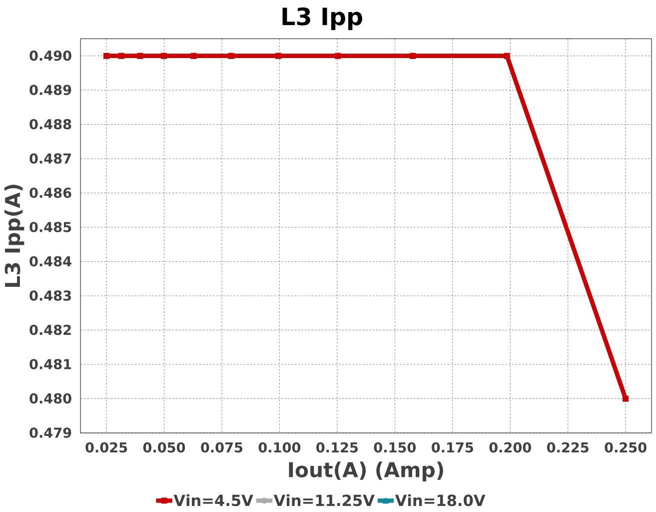


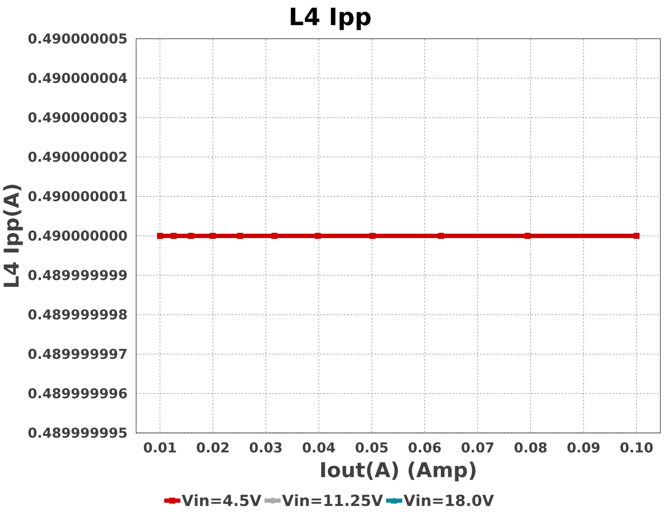
IC Tj

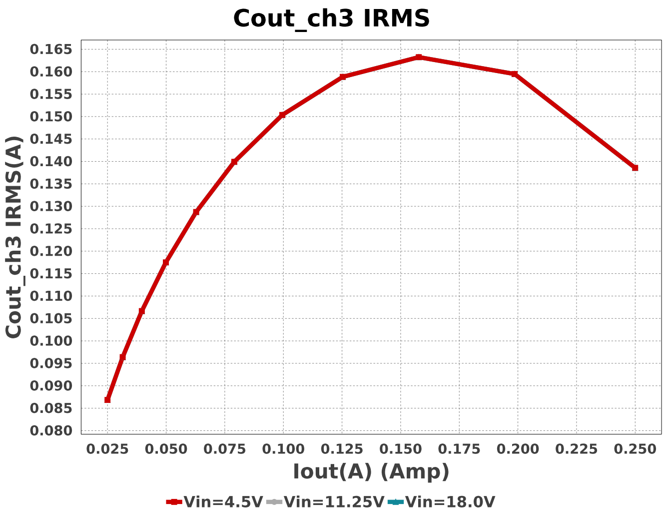


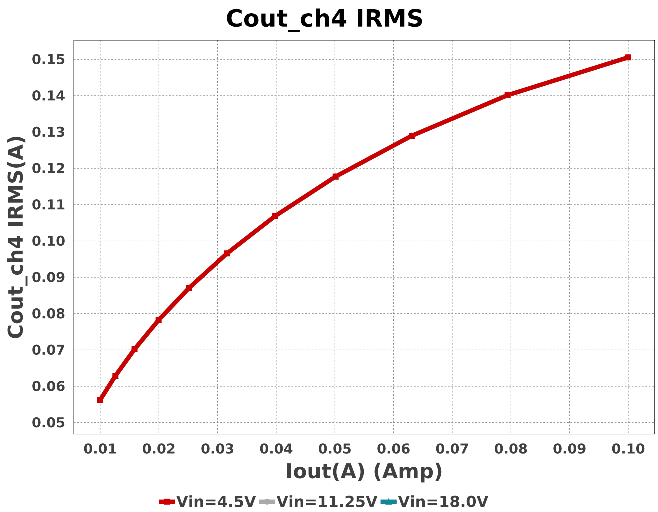

L3 PD
L3 PD(Watts)
Iout(A) (Amp)
Vin=4.5V Vin=11.25V Vin=18.0V


L4 PD
L4 PD(Watts)
Iout(A) (Amp)
Vin=4.5V Vin=11.25V Vin=18.0V

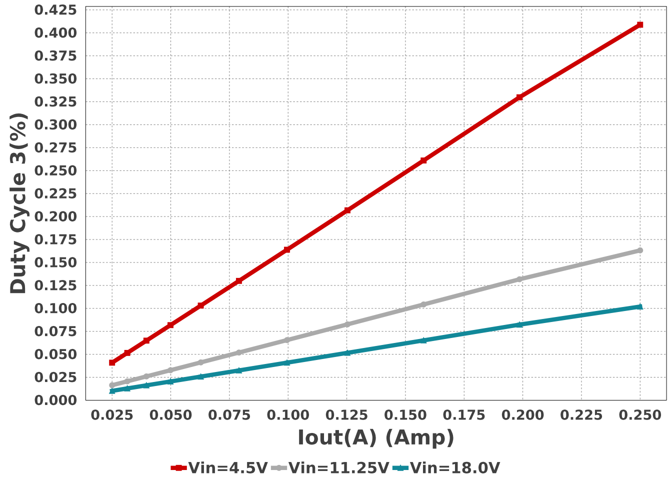

L3 Ipp
L3 Ipp(A)
Iout(A) (Amp)
Vin=4.5V Vin=11.25V Vin=18.0V


L4 Ipp
L4 Ipp(A)
Iout(A) (Amp)
Vin=4.5V Vin=11.25V Vin=18.0V

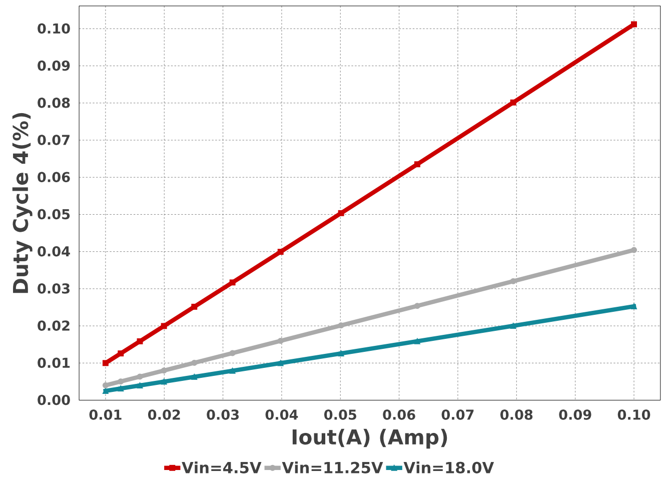

Cout_ch3 IRMS
Cout_ch3 IRMS(A)
Iout(A) (Amp)
Vin=4.5V Vin=11.25V Vin=18.0V


Cout_ch4 IRMS
Cout_ch4 IRMS(A)
Iout(A) (Amp)
Vin=4.5V Vin=11.25V Vin=18.0V

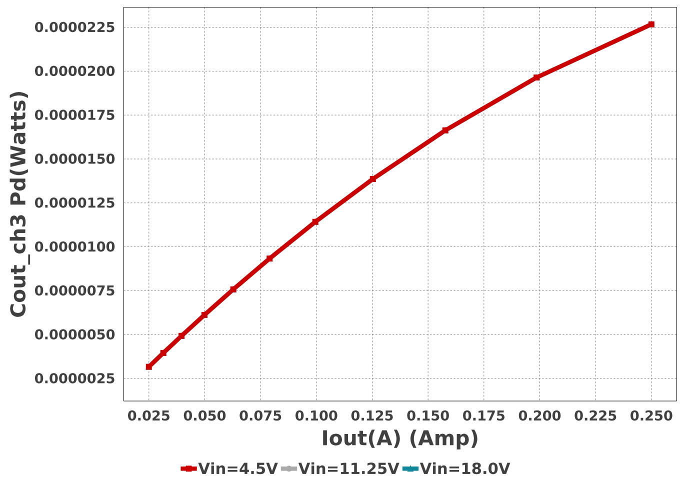
Duty Cycle 3



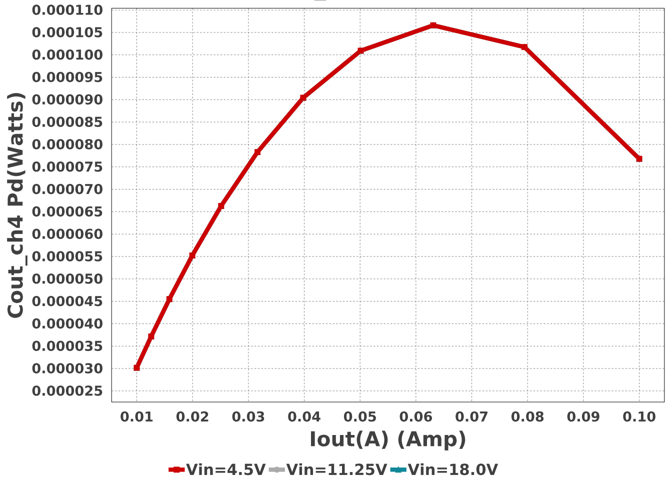
Duty Cycle 4



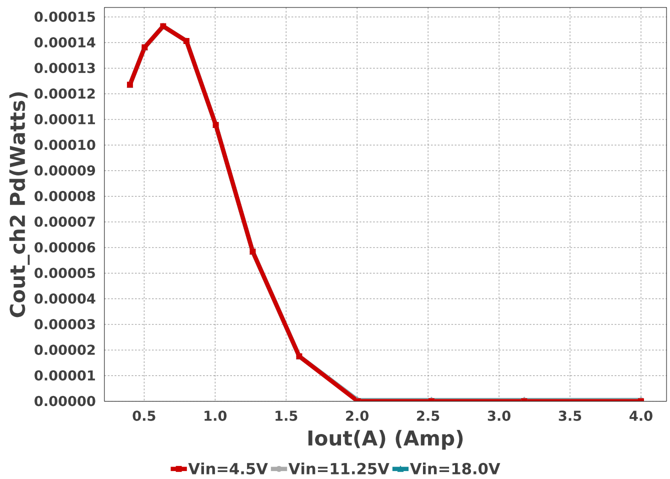
Cout_ch3 Pd



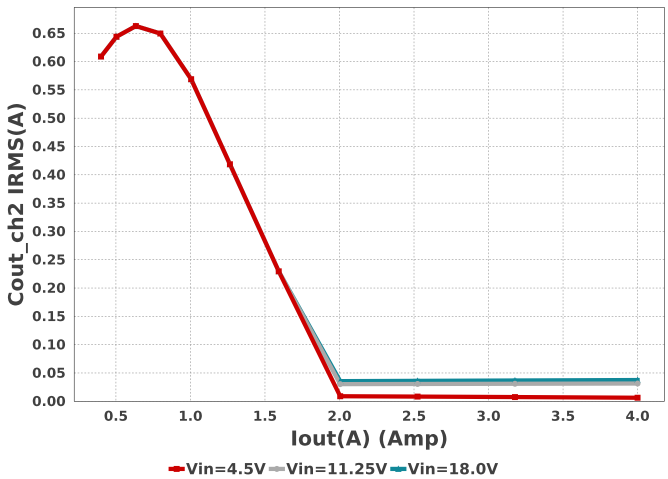
Cout_ch4 Pd

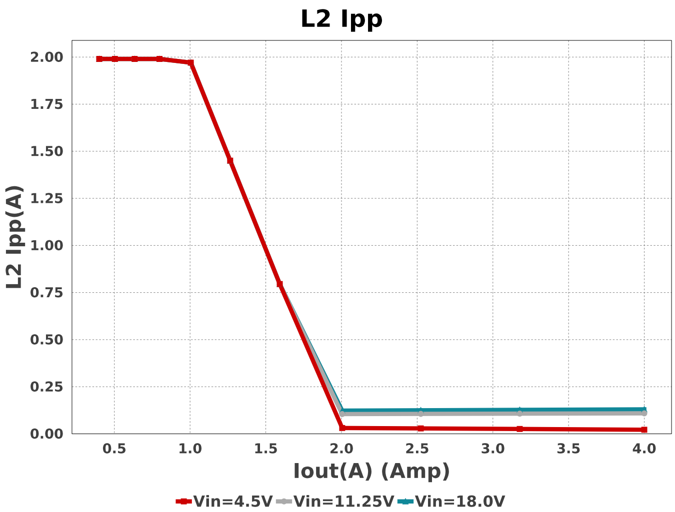


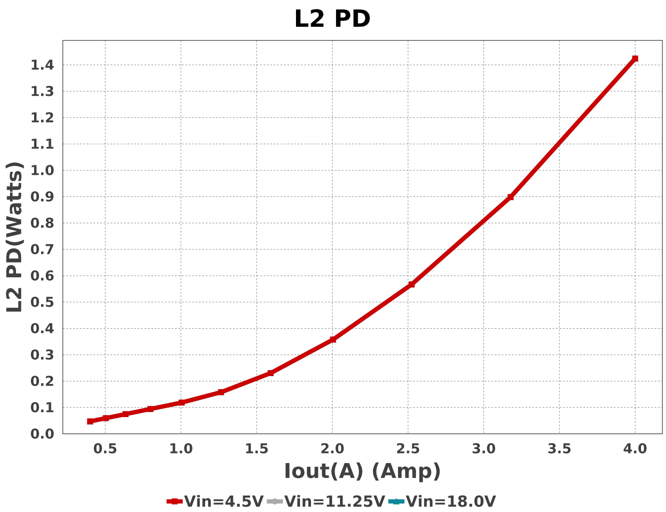
Cout_ch2 Pd

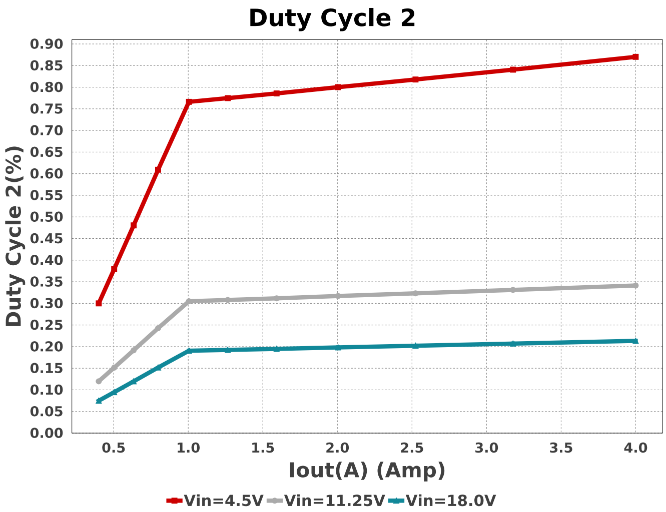


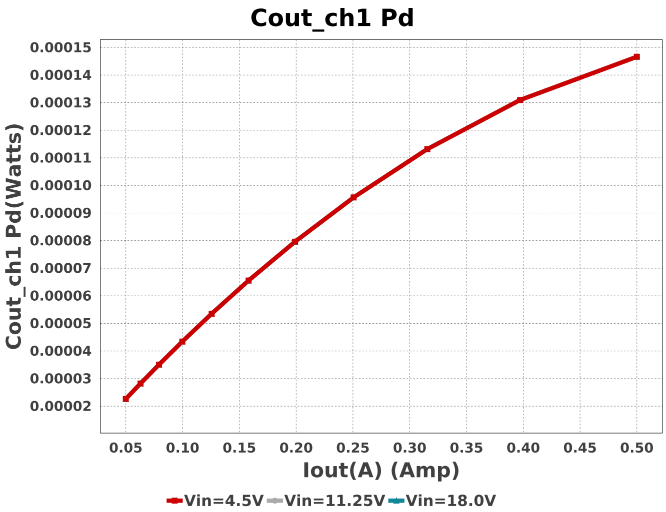
Cout_ch2 IRMS

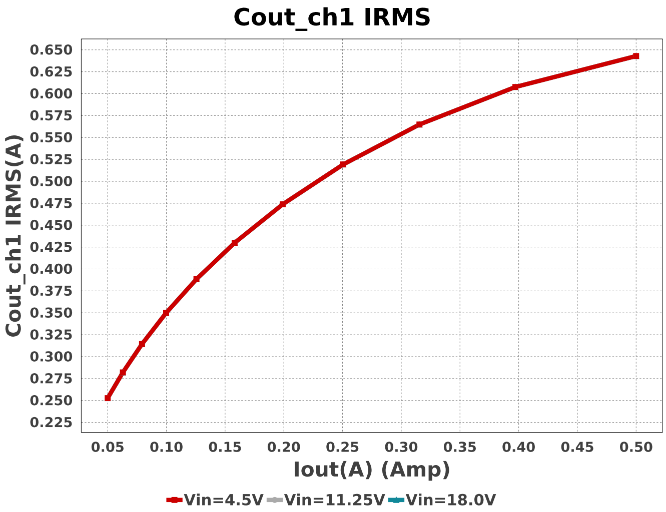


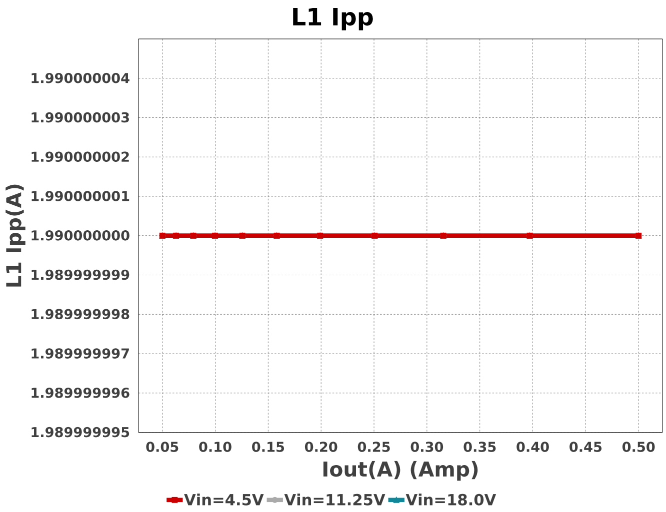

L2 Ipp
L2 Ipp(A)
Iout(A) (Amp)
Vin=4.5V Vin=11.25V Vin=18.0V

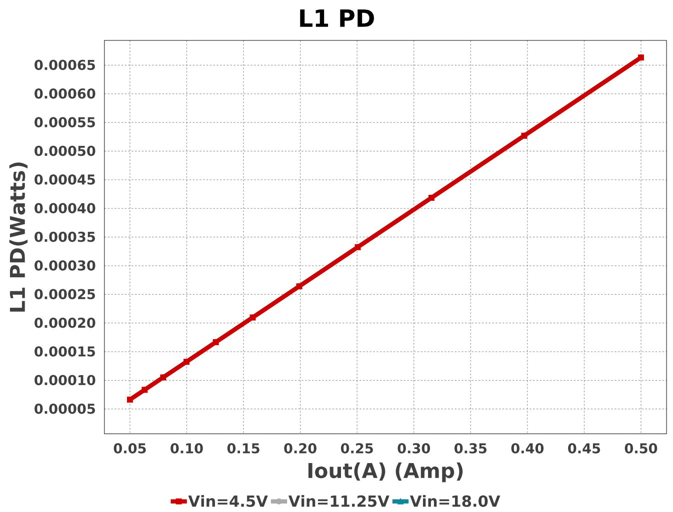

L2 PD
L2 PD(Watts)
Iout(A) (Amp)
Vin=4.5V Vin=11.25V Vin=18.0V

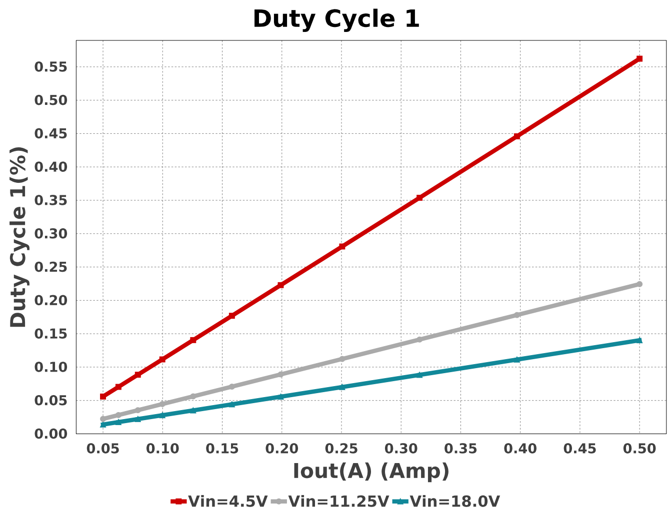

Duty Cycle 2
Duty Cycle 2(%)
Iout(A) (Amp)
Vin=4.5V Vin=11.25V Vin=18.0V


Cout_ch1 Pd
Cout_ch1 Pd(Watts)
Iout(A) (Amp)
Vin=4.5V Vin=11.25V Vin=18.0V


Cout_ch1 IRMS
Cout_ch1 IRMS(A)
Iout(A) (Amp)
Vin=4.5V Vin=11.25V Vin=18.0V


L1 Ipp
L1 Ipp(A)
Iout(A) (Amp)
Vin=4.5V Vin=11.25V Vin=18.0V





Operating Values

#	Name	Value	Category	Description
1.	Cout_ch1 IRMS	642.91 mA	Capacitor	Output Channel 1 Capacitor RMS ripple current
2.	Cout_ch2 IRMS	571.577 mA	Capacitor	Output Channel 2 Capacitor RMS ripple current
3.	Cout_ch3 IRMS	138.564 mA	Capacitor	Output Channel 3 Capacitor RMS ripple current
4.	Cout_ch4 IRMS	150.555 mA	Capacitor	Output Channel 4 Capacitor RMS ripple current
5.	IC Pd	536.59 mW	IC	IC power dissipation
6.	IC Tj	40.131 degC	IC	IC junction temperature
7.	IC Tolerance	10.0 mV	IC	IC Feedback Tolerance
8.	ICThetaJA Effective	18.88 degC/W	IC	Effective IC Junction-to-Ambient Thermal Resistance
9.	Iin Avg	379.68 mA	IC	Average input current
10.	L1 Ipp	1.99 A	Inductor	Inductor 1 peak to peak current
11.	L2Ipp	1.98 A	Inductor	Channel 2 Inductor Peak to peak Current
12.	L3 Ipp	480.0 mA	Inductor	Inductor 3 peak to peak current
13.	L4 Ipp	490.0 mA	Inductor	Inductor 4 peak to peak current
14.	Cout_ch1 Pd	146.63 µ	Power	Ouput channel 1 capacitor power dissipation
15.	Cout_ch2 Pd	108.9 µ	Power	Ouput channel 2 capacitor power dissipation
16.	Cout_ch3 Pd	76.8 µ	Power	Ouput channel 3 capacitor power dissipation
17.	Cout_ch4 Pd	22.667 µ	Power	Ouput channel 3 capacitor power dissipation
18.	IC Pd	536.59 mW	Power	IC power dissipation
19.	L1 Pd	663.333 µ	Power	Inductor1 power loss
20.	L2 Pd	118.076 m	Power	Inductor2 power loss
21.	L3 Pd	8.17 m	Power	Inductor3 power loss
22.	L4 Pd	3.267 m	Power	Inductor3 power loss
23.	Total Pd	474.296 mW	Power	Total Power Dissipation
24.	BOM Count	58	System Information	Total Design BOM count
25.	Duty Cycle 1	14.017 %	System Information	Duty cycle for Channel 1
26.	Duty Cycle 2	19.049 %	System Information	Duty cycle for Channel 2
27.	Duty Cycle 3	10.193 %	System Information	Duty cycle for Channel 3
28.	Duty Cycle 4	2.526 %	System Information	Duty Cycle channel 4
29.	Efficiency	93.06 %	System Information	Steady state efficiency
30.	FootPrint	1,000.0 mm^2	System Information	Total Foot Print Area of BOM components
31.	Frequency	457.742 Hz	System Information	Switching frequency
32.	Frequency Ch2	29.806 kHz	System Information	Switching frequency
33.	Frequency Ch3	190.672 kHz	System Information	Switching frequency
34.	Frequency Ch4	72.528 kHz	System Information	Switching frequency
35.	Iout1	500.0 mA	System Information	Iout1 operating point
36.	Iout2	1.0 A	System Information	Iout2 operating point
37.	Iout3	250.0 mA	System Information	Output Current channel 3

#	Name	Value	Category	Description
38.	Iout4	100.0 mA	System Information	Output Current channel 4
39.	Ch1 Mode	PFM	System Information	Channel 1 Conduction Mode
40.	Ch2 Mode	PFM	System Information	Channel 2 Conduction Mode
41.	Mode	PFM	System Information	Channel 3 Conduction Mode
42.	Mode	PFM	System Information	Channel 4 Conduction Mode
43.	Pout1	2.5 W	System Information	Total output power
44.	Pout2	3.3 W	System Information	Total output power
45.	Pout3	450.0 mW	System Information	Total output power
46.	Pout4	110.0 mW	System Information	Total output power
47.	Total BOM	NA	System Information	Total BOM Cost
48.	Vin	18.0 V	System Information	Vin operating point
49.	Vout Tolerance	2.967 %	System Information	Vout Tolerance based on IC Tolerance (no load) and voltage divider resistors if applicable
50.	Vout1	5.0 V	System Information	Operational Voltage 1
51.	Vout1_Actual	4.984 V	System Information	Vout Actual calculated based on selected voltage divider resistors
52.	Vout2	3.3 V	System Information	Operational Voltage 2
53.	Vout2Tolerance	2.804 %	System Information	Vout Tolerance based on IC Tolerance (no load) and voltage divider resistors if applicable
54.	Vout2_Actual	3.328 V	System Information	Vout Actual calculated based on selected voltage divider resistors
55.	Vout3	1.8 V	System Information	Operational Voltage 3
56.	Vout3Tolerance	2.394 %	System Information	Vout Tolerance based on IC Tolerance (no load) and voltage divider resistors if applicable
57.	Vout3_Actual	1.816 V	System Information	Vout Actual calculated based on selected voltage divider resistors
58.	Vout4	1.1 V	System Information	Operational Voltage 4
59.	Vout4Tolerance	1.816 %	System Information	Vout Tolerance based on IC Tolerance (no load) and voltage divider resistors if applicable
60.	Vout4_Actual	1.106 V	System Information	Vout Actual calculated based on selected voltage divider resistors

Design Inputs

Name	Value	Description
Iout	4.0	Maximum Output Current
Iout1	4.0	Output Current #1
Iout2	4.0	Output Current #2
VinMax	18.0	Maximum input voltage
VinMin	4.5	Minimum input voltage
Vout	1.8	Output Voltage
Vout1	1.8	Output Voltage #1
Vout2	1.8	Output Voltage #2
base_pn	TPS65400	Base Product Number
source	DC	Input Source Type
Ta	30.0	Ambient temperature
UserFsw	493.0 k	Customer Selected Frequency

WEBENCH® Assembly

Component Testing

Some published data on components in datasheets such as Capacitor ESR and Inductor DC resistance is based on conservative values that will guarantee that the components always exceed the specification. For design purposes it is usually better to work with typical values. Since this data is not always available it is a good practice to measure the Capacitance and ESR values of Cin and Cout, and the inductance and DC resistance of L1 before assembly of the board. Any large discrepancies in values should be electrically simulated in WEBENCH to check for instabilities and thermally simulated in WebTHERM to make sure critical temperatures are not exceeded.

Soldering Component to Board

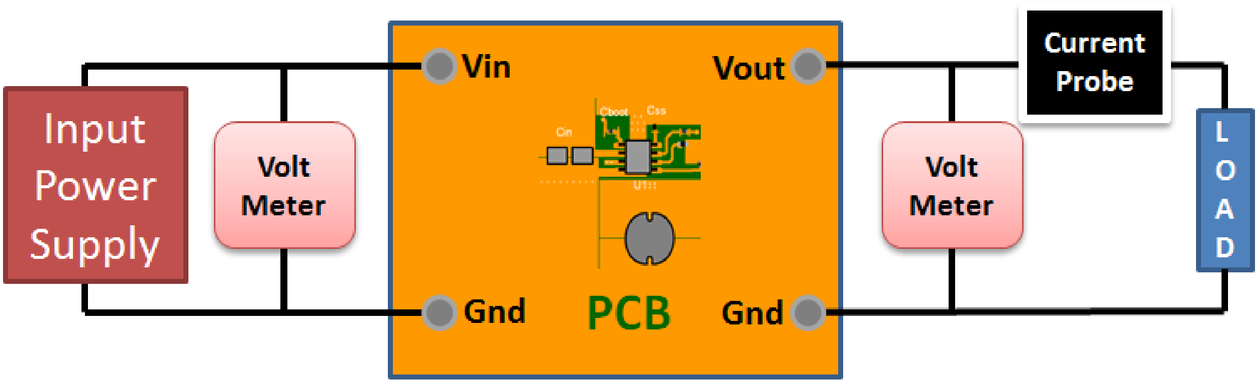
If board assembly is done in house it is best to tack down one terminal of a component on the board then solder the other terminal. For surface mount parts with large tabs, such as the DPAK, the tab on the back of the package should be pre-tinned with solder, then tacked into place by one of the pins. To solder the tab town to the board place the iron down on the board while resting against the tab, heating both surfaces simultaneously. Apply light pressure to the top of the plastic case until the solder flows around the part and the part is flush with the PCB. If the solder is not flowing around the board you may need a higher wattage iron (generally 25W to 30W is enough).

Initial Startup of Circuit

It is best to initially power up the board by setting the input supply voltage to the lowest operating input voltage 4.5V and set the input supply's current limit to zero. With the input supply off connect up the input supply to Vin and GND. Connect a digital volt meter and a load if needed to set the minimum Iout of the design from Vout and GND. Turn on the input supply and slowly turn up the current limit on the input supply. If the voltage starts to rise on the input supply continue increasing the input supply current limit while watching the output voltage. If the current increases on the input supply, but the voltage remains near zero, then there may be a short or a component misplaced on the board. Power down the board and visually inspect for solder bridges and recheck the diode and capacitor polarities. Once the power supply circuit is operational then more extensive testing may include full load testing, transient load and line tests to compare with simulation results.

Load Testing

The setup is the same as the initial startup, except that an additional digital voltmeter is connected between Vin and GND, a load is connected between Vout and GND and a current meter is connected in series between Vout and the load. The load must be able to handle at least rated output power + 50% (7.5 watts for this design). Ideally the load is supplied in the form of a variable load test unit. It can also be done in the form of suitably large power resistors. When using an oscilloscope to measure waveforms on the prototype board, the ground leads of the oscilloscope probes should be as short as possible and the area of the loop formed by the ground lead should be kept to a minimum. This will help reduce ground lead inductance and eliminate EMI noise that is not actually present in the circuit.



Design Assistance

1. Master key : 27AFC3A06A218B6F8EA41ED3B4C0DDB7[v1]

2. **TPS65400** Product Folder : http://www.ti.com/product/TPS65400 : contains the data sheet and other resources.

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